Nature Conservation 48: 31–56 (2022)
doi: 10.3897/natureconservation.48.79936
https://natureconservation.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
Nature Conservation
Launched to accelerate biodiversity conservation

Environmental citizen science in Greece: perceptions and attitudes of key actors

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Academic editor: J. Tzanopoulos | Received 29 December 2021 | Accepted 10 March 2022 | Published 7 April 2022

http://zoobank.org/1C1161C5-FBFF-4C80-A8C6-FDB74C46951A

Citation: Galanos C, Vogiatzakis IN (2022) Environmental citizen science in Greece: perceptions and attitudes of key actors. Nature Conservation 48: 31–56. https://doi.org/10.3897/natureconservation.48.79936

Abstract

Citizen Science (CS), the voluntary participation of lay people in scientific work, is well-established in the fields of nature conservation and biodiversity monitoring due to its potential to create large environmental datasets. This study aims to understand the familiarity, perceptions and attitudes towards CS of the key environmental actors in Greece. The target group consisted of employees and/or representatives of Environmental Non-Governmental Organisations (ENGOs), scientists and civil servants related to nature conservation. Quantitative data were collected using an electronic questionnaire, 178 fully completed questionnaires and subsequently eight semi-structured interviews with experts were conducted. Descriptive statistics were used to measure the familiarity and attitude of the actors, as well as the obstacles to the development of CS in Greece. We used Cronbach's test to measure the reliability of the used Likert scale and Kruskal-Wallis non-parametric test to identify significant differences amongst the three groups of actors. Qualitative data were analysed following a Thematic Analysis methodology. The results show that ca. 40% of the key actors are familiar with the terms and CS practice while over 65% with the concept. The general attitude of the actors towards CS is positive although concerns about data quality collected were highlighted. "Lack of cooperation culture", "Ignorance of the existence of the phenomenon" and "Lack of know-how" emerged as the most important obstacles to CS development in Greece. Although CS is present in Greece, it is not visible enough. The main reasons are that relevant projects employ different terms, are under-represented in the formal literature and include limited, if at all, project dissemination. There are significant differences regarding familiarity and the attitude towards CS between actors, but also similarities concerning the main obstacles. The study sets a baseline which can be employed to improve and further expand Environmental Citizen Science (ECS) in Greece.

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Keywords
Academia, government, mixed methods, nature conservation, NGOs, survey

Introduction

Public participation and knowledge production can take many forms (Shanley et al. 2019) with Citizen Science being, perhaps, the most widely used and better understood by the public. In fact, the practice of Citizen Science (CS) is not new, since for most of the recorded history, it was the public that advanced science - often by just observing nature (Miller-Rushing et al. 2012). The history of amateurs conducting research and collecting environmental data from the field is very old and expands from Norway to France, Japan to China and US (Miller-Rushing et al. 2012). Undoubtedly, the current concept of CS, that is, the involvement of the public in scientific work, has evolved primarily over the past two decades (Cohn 2008). This is obvious by a number of indicators, such as the steep rise in the biodiversity-orientated CS projects over the last 30 years (Theobald et al. 2015), the expansion of scientific reports and peer-reviewed articles resulting from CS project data (Bonney et al. 2014; Vann-Sander et al. 2016) and the establishment of professional CS organisations around the world, especially in the US, Europe and Australia (Ellwood et al. 2017). Moreover, CS projects cover a breadth of scientific disciplines from biology and biodiversity data collection, to the interpretation of astronomic images, archaeology and chemistry (Dickinson et al. 2010; Conrad and Hilchey 2011; Franzoni and Sauermann 2014; Kullenberg and Kasperowski 2016).

There are certain factors which enabled the proliferation of CS during the last decades. One of the most important drivers is the technological breakthrough and all the new possibilities for data gathering and dissemination of information from the public (Silvertown 2009; Dickinson et al. 2012). These technological innovations include the internet, smartphones, Global Positioning Systems (GPS), web geographic information system applications, the increased availability of domestic internet connections and the reduction of costs for computer storage. On one hand, the increasing realisation amongst professional scientists that the public can provide free labour, skills, computing power and even funding and, on the other hand, the growing demands from large research funders for public engagement led to new and innovative CS projects (Cohn 2008; Silvertown 2009). In addition to technological factors, social factors also played an important role in the expansion of CS. Two of those prevail. The first one is the growth in the population of well-educated individuals who possess the skills to perform scientific tasks, but do not use their knowledge in their daily life. The second factor is the increase in leisure activities as a result of the reduction in working hours in advanced economies (Haklay 2013).

CS is best established in biological sciences and, in particular, in biodiversity and natural resources monitoring (Follett and Strezov 2015; Kullenberg and Kasperowski 2016; Schade and Tsinaraki 2016; Pettibone et al. 2017; Pocock et al. 2017). Nowadays, probably the principal reason for this dominance of biology-related CS projects

is the realisation of scientists that CS is perhaps the only practical way to gather data at large geographical scales, time periods and private lands. Such large datasets are necessary for biologists to understand the processes and to address ecological questions, such as climate change, patterns of migration and spread of diseases (Dickinson et al. 2010).

In recent years, a number of studies reviewed the field of Environmental Citizen Science (ECS), to determine the effective use of the data collected in biodiversity research (Theobald et al. 2015; Chandler et al. 2017), to assess the diversity and evolution of the ECS field (Pocock et al. 2017), to understand the diversity of CS in specific countries (Pettibone et al. 2017) or to assess projects that can be of relevance to environmental European policy (Bio Innovation Service 2018).

Studies about CS as a social phenomenon have dealt mainly with how the citizens react, participate and understand it, with emphasis mainly on motivations (Alender 2016; Domroese and Johnson 2017) or barriers to participation (Martin et al. 2016). For example, information from interviews with representatives of biodiversity-recording organisations shed light on motivations of citizens to participate in biodiversity-monitoring CS projects and demonstrated that people from socio-economically deprived areas are under-represented in those schemes (Hobbs and White 2012). During recent years, emphasis is given in motivation to participate in online CS projects (Raddick et al. 2010; Nov et al. 2014), the use of smartphones (Land-Zandstra et al. 2016b) and gamification strategies (Greenhill et al. 2016) to enhance citizens' participation. What remains limited though, are insights about the main initiators/groups of actors of ECS projects (ENGOs, scientists, governmental organisations) and interaction between those engaged (Rotman et al. 2012; Weng 2015). Motivation and data collection are perceived differently by citizens and groups of actors (Jiang et al. 2018) with scientists more concerned about the quality of data and peers' approval (Riesch and Potter 2014; Burgess et al. 2017) rather than the opinion and needs of citizens when engaging in ECS projects.

In Greece, most of the examples of ECS projects are usually initiated by ENGOs, such as the Hellenic Ornithological Society (HOS) or the Hellenic Marine Environment Protection Association (HELMEPA). The country may benefit from such projects given that: a) its biodiversity is considered to be one of the richest in endemism in Europe and in the Mediterranean (Georghiou and Delipetrou 2010) and that: b) due to the recent economic crisis, the adoption of an austerity programme (Matsaganis 2014) has weakened environmental administration and surveillance mechanisms, adding extra threats to Greek biodiversity (Lekakis and Kousis 2013). Therefore, CS has a distinct role to play as a mechanism to support nature conservation as well as public engagement with nature and science (Devictor et al. 2010). Nevertheless, the specific cultural and socio-economic characteristics of each country play a decisive role in the success or failure of such projects. These might be expressed through past environmental history, collaborative culture, legal frameworks and organisational context. Recommendations exist in literature, but most studies come from relatively rich, industrialised countries and little knowledge exists for the specific challenges of initiating monitoring schemes in different contexts (Danielsen et al. 2003) with few perhaps exceptions (e.g. Loos et al. 2015). Although users' profiles are important factors in shaping citizen

science (Amarasinghe et al. 2021; Aristeidou et al. 2021), this study focuses on three specific sectors (Public bodies, Research/Academic Community, ENGOs) since they are the ones which deal with conservation on a day-to-day basis, can formulate policies and/or influence decision-making.

The aim of the study is to understand the perceptions and attitudes of the main actors engaged in environmental management and nature conservation in Greece towards CS. Three target groups, environmental data collection actors, from ENGOs, research centres and/or higher educational institutions (Universities/Technological Institutes) and government sectors were selected. To achieve this aim, five key questions were addressed:

- to what extent are the three groups of actors familiar with the term, the concept and practice of CS?
- what is the attitude of the actors towards CS?
- which are the main obstacles to the development of CS in Greece?
- which are the main reasons for the reduced visibility of the term in Greece?
- are there significant differences amongst the actors in relation to the above-mentioned questions?

Materials and methods

The research approach was based on mixed methods and, more specifically, an explanatory sequential, where a quantitative step was first conducted, followed by a qualitative part to elucidate the most interesting findings. In the first quantitative phase of the study, survey data were collected from a number of respondents using an electronic questionnaire (Appendix 1 Questionnaire). The sample was drawn from a population of professionals within the field of environmental monitoring and nature conservation: employees and members of ENGOs, environmental scientists working on research centres and higher educational institutions (Universities/Technological institutes) and civil servants and government authorities all engaged in the topic of environmental conservation. This represents a convenient sampling technique; thus, our results cannot be considered representative and cannot be generalised. However, for exploratory studies like this one, convenience samples are considered sufficient (Sue and Ritter 2007, 25).

Our sample comprised 644 emails, both personal and organisational. Contact details including e-mail addresses used in this study were publicly available on the internet through the organisations' official website (for researchers and civil servants) and the database for ENGOS maintained and regularly updated by the National Centre for Social Research in Greece (1 EKKE/IAAK. (n.d.). Retrieved 17 February 2019, from http://ekke.gr/estia/eng pages/eng index.htm)

The questionnaire included questions on demographics, familiarity with the term, the concept and the practice of CS, using a Likert-scale with an aim to capture the perceptions and attitudes of the actors towards CS. The statements expanded from the

most cited positive effects of the practice (Devictor et al. 2010; Dickinson et al. 2010; Roy et al. 2012; Science Communication Unit 2013; Pocock et al. 2014) up to the most common reasons for reluctance to accept it, for example, data quality (Rotman et al. 2012, 2014; Hyder et al. 2015; Minkman et al. 2015; Geoghegan et al. 2016; Burgess et al. 2017; Haklay et al. 2017), as well as a question about the main obstacles to the development of CS in Greece. All the questions of the survey were compulsory, except for a question about the name of the organisation and the last field where the respondents were asked to provide their e-mails in case they were also willing to provide an interview. For the compulsory questions, the option "I do not know / I do not answer" or "I do not answer" was also given to the respondents.

We piloted the questionnaire by distributing to six researchers, one representative of an ENGO and a public servant who provided initial feedback. Their answers were not included in the final dataset, while those respondents did not answer the final version of the questionnaire. The survey was initiated on the 23 April 2018 and it was closed on the 17 May 2018. The software used to publish the survey and collect the responses was LimeSurvey Version 2.06, an open-source online survey tool installed on the servers of CIHEAM-MAICh. The questionnaire was designed to take approximately ten minutes.

Those quantitative data were used to answer four out of the five research questions. The quantitative data from the survey were imported and analysed in Rstudio Version 1.1.453 (R version 3.3.3). Ggplot2, reshape2 and sjp.likert functions in R were used to produce the graphs. Descriptive statistics, such as summaries, percentages, means and standard deviations, were also calculated.

After the initial data analysis, the fourth research question was formulated. The qualitative phase was conducted to help answer the fourth research question and explain the most important results of the third research question. For the second phase of the study, semi-structured interviews of eight experts were conducted.

For the purposes of the qualitative part of the research, a smaller sample of 30 possible interviewees was created after an initial analysis of the questionnaire data. The possible interviewees were selected on the basis of two criteria: they were familiar with the term and/or the practice of CS and they had responded positively in the final question of the survey concerning their availability for a telephone interview. First, the participants that met the above-mentioned criteria were identified and then ten for each group of actors were randomly selected. Even if the aim of the semi-structured interviews was to interview representatives from all three groups of actors, unfortunately, we did not receive a positive reply from any representative of the public sector. Thus we interviewed five employees/representatives from ENGOs and three scientists from the research/academic sector.

The interviews were undertaken from 26 June to 17 July 2018. The interview guide was composed of one introductory question, two main topics of discussion and a closing part where the interviewees were asked to write anything additional which they considered important. The introductory question was how the interviewee's work is related to environmental monitoring and nature conservation. One main topic of discussion was about possible reasons for the non-visibility of CS in Greece. Regarding

the other topic, the interviewees were asked to provide their opinion about the first two obstacles to the development of CS in Greece as depicted from the survey.

In particular, the methods used to answer the research questions were as follows: for the first research question, we calculated percentages from questions B3, B4 and B5 of the questionnaire (see Appendix 1). For the second research question, we employed questions C1 and C3 of the questionnaire (Appendix 1). Question C1 was a Likert-scale question of eighteen statements. Alpha function was used to calculate Cronbach's a for reliability analysis. To measure the positive or negative attitude of the respondents towards the Likert statements, we assigned numeric values from 1 up to 4 corresponding to their level of agreement (Not at all (1), A little (2), Significantly (3), A lot (4)). The negative wording statements were reversed. Then the sum for each statement was divided by the number of the respondents minus the "I don't know / I don't answer" cases. Summing the means of all the 18 statements, we concluded with a score between 18 and 72, depicting the attitude of the respondents towards CS. Then this score was converted to a 0–100 scale to facilitate interpretation. The same process was followed for all the respondents and for each group of actors. From question C3, a table of percentages was produced.

For the third research question, at first, we employed question C2 of the questionnaire and percentages were calculated. During the semi-structured interviews (see Appendix 2 for the list of interviewees), some clarification concerning the first two main obstacles was asked by the experts. The answers were analysed using a Thematic Analysis approach (Attride-Stirling 2001).

For the fourth research question, we analysed the transcribed experts' interviews using a thematic network analysis approach (Attride-Stirling 2001) to RQDA software. In total, 125 codes were generated. Out of these codes, fourteen categories, or themes, emerged in relation to the reasons for the non-visibility of the practice in Greece and to interpret better the two main obstacles in the development of the CS in Greece according to the actors.

Finally, for the fifth research question, comparisons amongst the three groups of actors were performed using the Kruskal-Wallis test, followed by post-hoc pairwise comparisons with the Dunn-Bonferroni approach.

Results

Out of the 644 e-mails sent, we received 80 delivery failures with 564 emails reaching their target. The survey resulted in 178 fully completed questionnaires, so a return rate of about 30% which is the usual response rate for web-based surveys (Sue and Ritter 2007, 8). From the survey respondents, 16.9% work or represent an ENGO, 30.9% are researchers and 52.2% are working in public bodies.

Regarding familiarity of the actors with the term (see question B3), 41.6% of the respondents answered "Yes", 57.9% answered "No" and 0.6% choose the option "I don't know/I don't answer". The percentages differed significantly when we examine the results within the three different groups of actors. Researchers were the most

familiar group with 72.7% answering that they know the term CS, followed by the representatives from ENGOs with 53.3% and then the public servants with 19.4%.

To investigate the familiarity of the actors with the concept, we employed question B4, with 34.8% of the respondents answering "None of the above", which means that the remaining 65.2% knew at least one of the terms which relate to CS (Fig. 1).

The researchers are the ones who were most familiar with the concept of CS since they had the lowest percentage (16.4%) for the option "None of the above" when asked if they know the terms. The second familiar group was the NGOs with 23.3% followed by the public sector with 49.5% (Fig. 2).

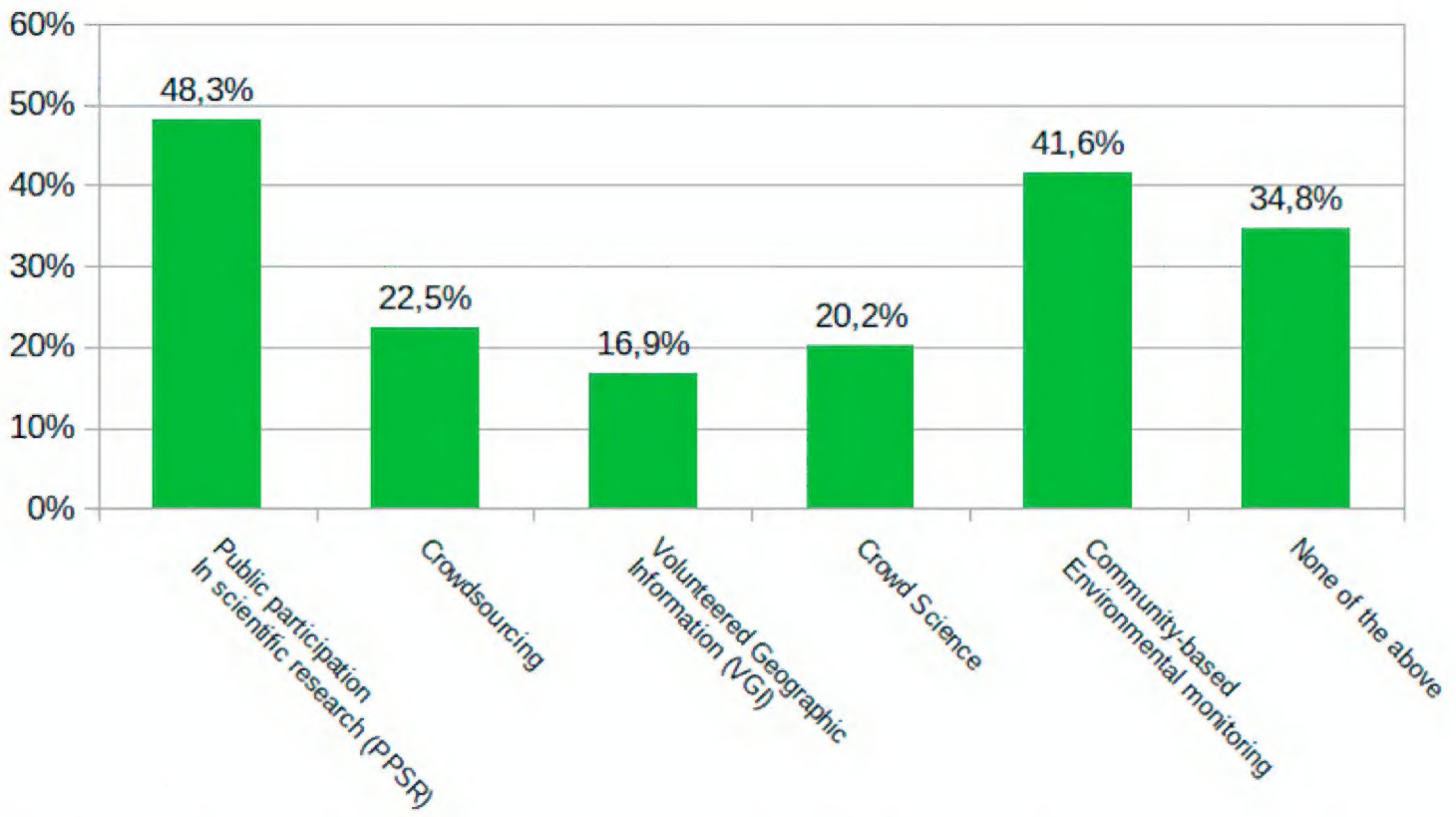

Figure 1. Responses to question B4 "Do you know any of the following terms" (all respondents).

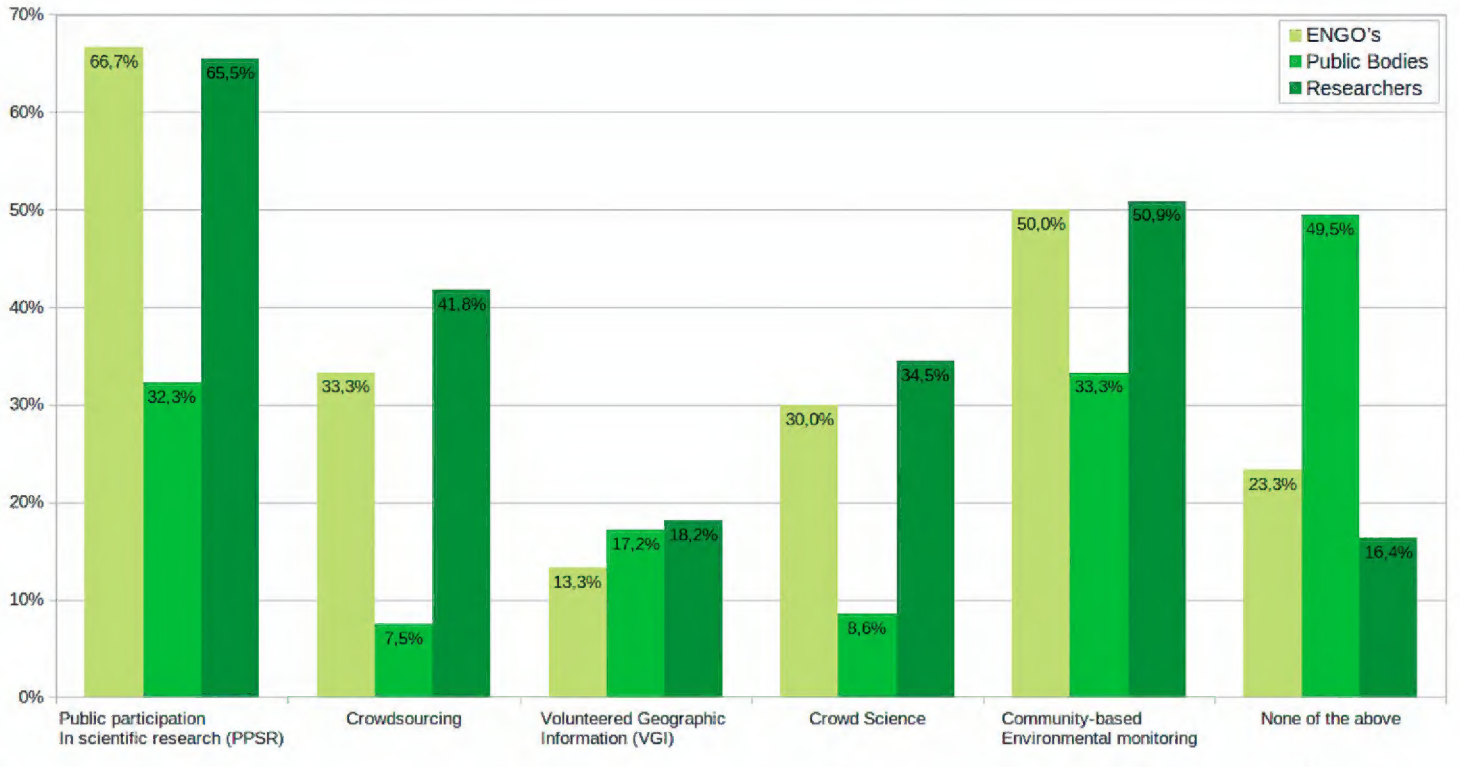

Figure 2. Responses to question B4 "Do you know any of the following terms" (per group of actors).

Finally, regarding the familiarity of the actors with the actual practice of CS, we employed question B5 for which 39.3% of the respondents answered "Yes" to that question, 57.3% answered "No" and 3.4% chose the option "I don't know/I don't answer".

In order to answer the second research question of this study, we analysed the responses to question C1 and C3 of the questionnaire. The Likert scale used in C1 had internal reliability: Cronbach's a = 0.79. As a general rule of thumb, reliabilities with Cronbach's a above 0.7 are considered acceptable (Cortina 1993).

For the analysis of the Likert scale, numeric values were assigned to the levels of agreement of the respondents and then the mean was calculated for each item and a total sum of all the items. Since the range of the numeric values that we chose to assign was from 1 up to 4, the mean of each item falls within this range. According to this rationale, an item with a mean close to the upper (4) or lower (1) value has a clearer depiction (positive or negative) of the attitude of the actors towards the relevant statement. On the other hand, items with a mean value around 2.5 are statements more debatable that divide the respondents. Moreover, the scores of the negative wording statements have been reversed. The sum of the items - for all the respondents and for each group separately - was converted to a 0–100 scale for better interpretation. The scores for all the respondents and for each group of actors are presented in Table 1.

Finally, regarding the attitude of the actors towards CS, question C3, 76.4% of the respondents answered "Yes", 6.7% answered "No" and the remaining 16.9% chose the option "I don't know/I don't answer".

Within the groups of actors, the researchers and the employees/representatives of the NGOs had very similar answers. Around 90% believe that a CS programme would be a positive addition to their activities. The majority of the public sector (63.4%) was also positive; 26.9% answered "I don't know/I don't answer" and 9.7% chose the option "No" (Fig. 3).

To answer the third research question of this study, we used the responses to question C2. The results are presented in Fig. 4 for all the respondents and Fig. 5 for each group of actors. In these two figures, the dark green colour represents the three most important obstacles while light green shows the obstacles above 20%. The three most important obstacles for all the respondents were "Lack of cooperative culture", "Ignorance of the existence of the phenomenon" and "Lack of know-how". The first two obstacles stand out from the rest with 53.9% and 45.5%, respectively. The third obstacle was selected in ca. 30% of the responses, while the rest of the obstacles received under 25%.

Table 2 presents all the obstacles above 20% - for all the respondents and for each group of actors. From this table, it becomes obvious that five obstacles are very important for all the actors while some obstacles are of importance mainly for the public bodies and the researchers.

Following the quantitative analysis, we aimed to further clarify the first two obstacles. Therefore, during the interviews, we asked the experts what they believe the reasons were for those obstacles. Regarding the first obstacle "lack of cooperation culture", one important reason that was mentioned by the majority of the interviewees was the problematic operation of the State. This statement refers to a range of activities, such

as inconsistent policies and official committees that never function, the absence of participatory processes, no continuity in the priorities of the ministries due to political changes and long delays. Some other reasons were: the absence of volunteering mentality in Greece, types of behaviour that make difficult the relationships between the research community and the NGOs, lack of proper information and finally, the lack of a culture of acknowledgment by both the State and the researchers creates problems in possible collaborations with the public and NGOs.

Regarding the second obstacle "Ignorance of the existence of the phenomenon", two main reasons emerged through the interviews. We termed the first one "Lack of external stimulus" to refer to bureaucratic organisations with no motivation for participatory research or practices. The second reason was that the actors (ENGOs, researchers, public bodies) have not communicated the term successfully to the general public, so there is a lack of relevant information.

Table 1. Mean values per statement of the Likert scale and total sum of the means.

Statements	All	NGOs	Public Bodies	Researchers
CS can support the collection of environmental data on a large geographic scale	3.04	3.39	2.83	3.19
Data gathered by citizens is not sufficiently reliable to use for public policy	2.48	3.00	2.34	2.44
CS can help environmental awareness of ordinary citizens	3.46	3.62	3.27	3.69
The quality of environmental data collected by non-professionals is inadequate for scientific research	2.55	3.07	2.41	2.49
CS can contribute to the collection of environmental data in cases of limited resources (Time, Money)	3.14	3.46	3.08	3.07
Increasing the phenomenon of CS may pose a threat to some jobs of professional scientists	3.45	3.79	3.31	3.49
CS can support government agencies in collecting environmental data as a cost-effective alternative	2.61	2.86	2.60	2.51
CS can help democratise science through the involvement of citizens in scientific processes	2.64	3.07	2.47	2.70
The collection of environmental data with low-cost devices such as smartphone sensors is un-acceptable in the context of scientific research	3.15	3.56	2.99	3.21
CS can help create social cohesion through voluntary engagement of citizens, building skills and engaging in problem-solving processes	3.12	3.48	2.97	3.16
Citizens do not have enough incentives to volunteer in scientific research	2.31	2.10	2.29	2.45
Citizens cannot follow the protocols required by the collection of environmental data in the context of scientific work	2.52	2.59	2.50	2.53
CS can help to involve different stakeholders in policy design and management of local ecosystems	2.93	3.24	2.75	3.05
CS can help to create creative activity for people outside the labour market, for example, retirees	3.01	3.28	2.87	3.09
With appropriate training, ordinary citizens can collect environmental data of satisfactory quality	3.15	3.62	2.99	3.18
CS can support local communities to protect the environment	3.27	3.55	3.12	3.36
Collaboration with volunteers from the general public is usually problematic	2.83	3.03	2.67	3.00
The resources required (time, money) for a citizens' science programme are excessive in relation to the results it generates	3.01	3.32	2.85	3.04
Sum (range 18-72)	52.67	58.05	50.30	53.68
Sum (conversion 0-100 range)	**64.21**	**74.16**	**59.82**	**66.08**

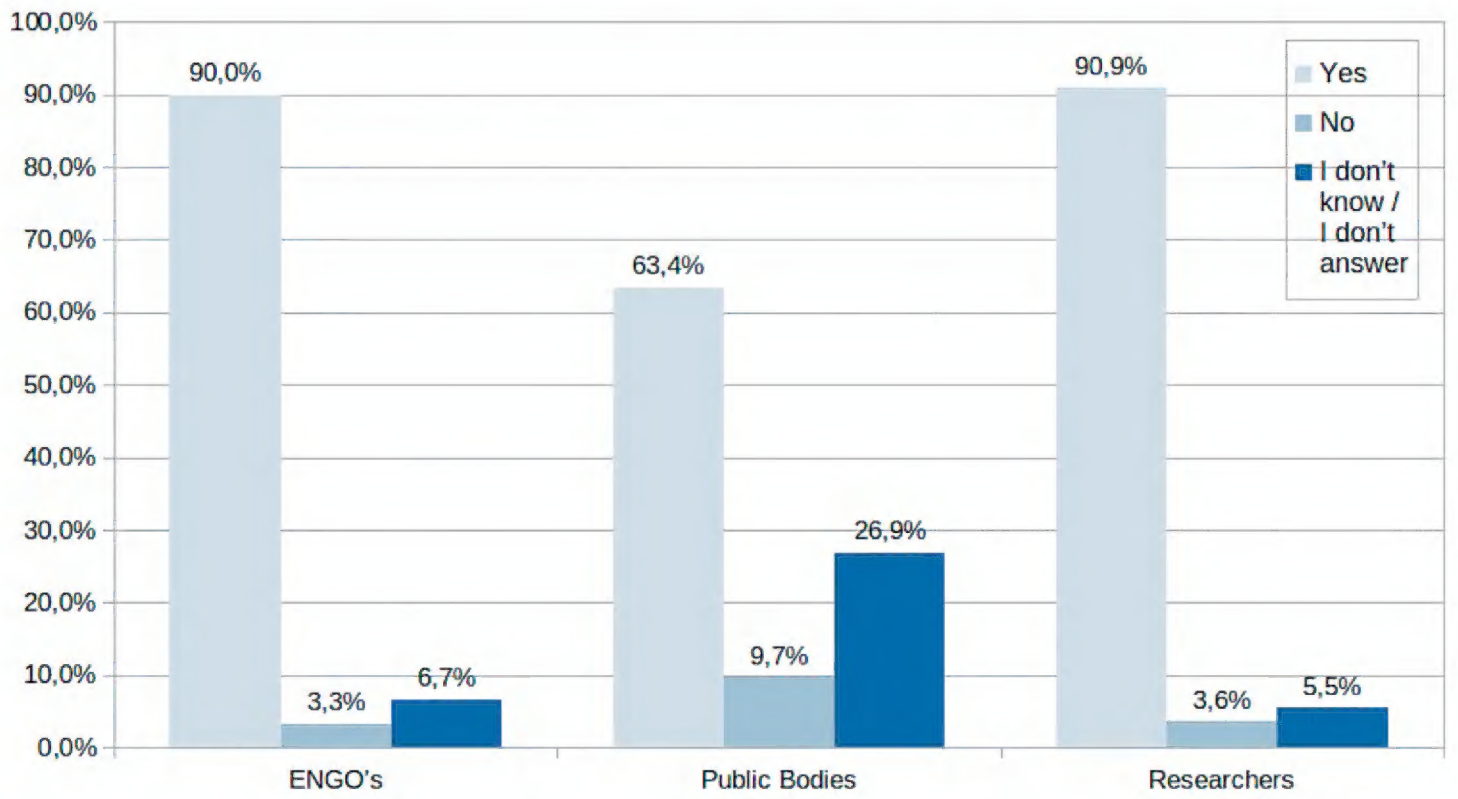

Figure 3. Responses to question C3 of the questionnaire (per groups of actors) "Do you think that a Citizen Science programme would offer something positive to your organisation's activities or to the research you are conducting?"

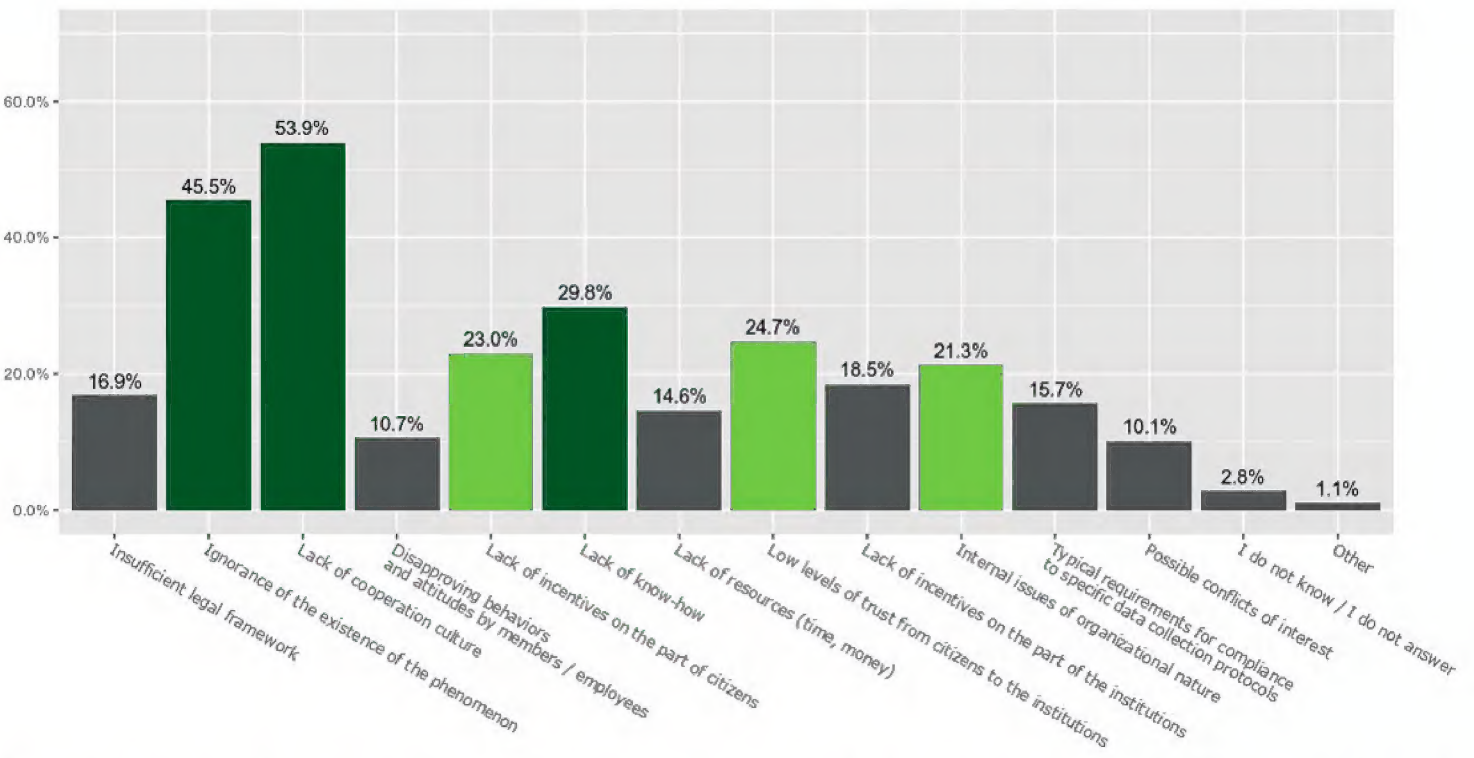

Figure 4. Main obstacles to the development of Citizen Science in Greece (all respondents). Dark green shows the first three obstacles, light green obstacles above 20%.

During the semi-structured interviews, the interviewees were asked their opinion about the main reasons for the reduced visibility of the term in Greece. A reason that was reported is that the researchers who participate in CS projects often do not publish due to data quality issues. Another reason is that CS within the organisations, if it exists, is a side-line activity, amongst others. Thus, it is not easy to be promoted because promotion needs extra time and effort and the resources normally are scarce. In addition, most of the CS projects that are initiated with some form of EU funding (e.g.

Horizon or LIFE+ programmes), do not continue once the funding is over (usually the end of the project). Therefore, there is insufficient time to develop and disseminate their added value in the society. Finally, the majority of the interviewees mentioned that the term is not so visible in Greece because organisations that run relevant projects do not use the term Citizen Science.

The familiarity with the term, the concept and the practice of CS differed significantly amongst the three groups of actors as demonstrated by the Kruskal-Wallis test (Table 3). Post-hoc pairwise comparisons, using the Dunn-Bonferroni test, revealed that respondents from public bodies are significantly less familiar with CS than respondents from ENGOs and the researchers.

From the eighteen statements of the Likert scale, the Kruskal-Wallis test depicted eight statements as statistically significant (Table 4). The most contradictory pair of actors is "ENGOS-public bodes" which is statistically significantly different in seven statements from the eighteen of the scale. Then the pair "researchers-public bodies" is significantly different in three statements and lastly, the "ENGOs-researchers" pair differs significantly on two occasions.

Figure 5. Main obstacles to the development of Citizen Science in Greece (per group of actors). Dark green shows the first three obstacles, light green obstacles above 20%.

Table 2. Obstacles over 20% for all the respondents and per group.

Obstacles	All	ENGOs	Public Bodies	Researchers
Lack of cooperation culture	53.9% (1st)	60% (1st)	45.2% (1st)	65.5% (1st)
Ignorance of the existence of the phenomenon	45.5% (2nd)	56.7% (2nd)	44.1% (2nd)	41.8% (2nd)
Lack of know-how	29.8% (3rd)	26.7% (4th)	31.2% (3rd)	29.1% (3rd)
Low levels of trust from citizens to the institutions	24.7% (4th)	36.7% (3rd)	20.4% (5th)	25.5% (4th)
Lack of incentives on the part of citizens	23.0% (5th)	26.7% (4th)	20.4% (5th)	25.5% (4th)
Internal issues of organisational nature	21.3% (6th)		25.8% (4th)	20.0% (6th)
Lack of incentives on the part of the institutions			20.4% (5th)	20.0% (6th)
Typical requirements for compliance to specific data collection protocols				21.8% (5th)
Insufficient legal framework			25.8% (4th)	

Table 3. Comparisons of familiarity with Citizen Science using the Kruskal-Wallis test followed by pairwise comparisons using the Dunn-Bonferroni test.

Familiarity	Kruskal-Wallis test			Pairwise comparisons		
	H	df	P-Value	Pairs	P-Value	r
With the term	42.6	2	0.000	ENGOs – Public **Bodies**	**0.0014***	3.3
				ENGOs – Researchers	0.1302	-1.71
				Researchers – Public **Bodies**	**0.0000***	-6.36
With the concept	18.68	2	0.000	ENGOs – Public **Bodies**	**0.0138***	-2.6
				ENGOs – Researchers	0.7806	0.64
				Researchers – Public **Bodies**	**0.0001***	4.07
With the practice	17.02	2	0.000	ENGOs – Public **Bodies**	**0.0193***	2.49
				ENGOs – Researchers	0.8105	-0.61
				Researchers – Public **Bodies**	**0.0002***	-3.89

*: Statistically significant difference detected at p ≤ alpha/2, alpha = 0.05 (after Bonferroni adjustment for multiple comparisons).

Table 4. Statistically significant Likert-scale statements using the Kruskal-Wallis test followed by pairwise comparisons using the Dunn-Bonferroni test.

Familiarity	Kruskal-Wallis test			Pairwise comparisons		
	H	df	P-Value	Pairs	P-Value	r
CS can support the collection of environmental data on a large geographic scale	11.52	2	0.003	ENGOs – Public **Bodies**	**0.0072***	-2.82
				ENGOs – Researchers	0.8027	0.62
				Researchers – Public **Bodies**	**0.0120***	-2.65
Data gathered by citizens is not sufficiently reliable to use for public policy	11.24	2	0.004	ENGOs – Public **Bodies**	**0.0021***	-3.2
				ENGOs – Researchers	**0.0047***	-2.95
				Researchers – Public **Bodies**	1	0.01
The quality of environmental data collected by non-professionals is inadequate for scientific research	12.81	2	0.002	ENGOs – Public **Bodies**	**0.0026***	3.14
				ENGOs – Researchers	**0.0009***	-3.43
				Researchers – Public **Bodies**	0.7264	-0.7
CS can help democratise science through the involvement of citizens in scientific processes	6.99	2	0.030	ENGOs – Public **Bodies**	**0.0175***	2.52
				ENGOs – Researchers	0.3469	1.2
				Researchers – Public	0.1942	-1.52
The collection of environmental data with low-cost devices, such as smartphone sensors, is un- acceptable in the context of scientific research	7.89	2	0.019	ENGOs – Public	**0.0091***	-2.74
				ENGOs – Researchers	0.206	-1.49
				Researchers – Public **Bodies**	0.2406	1.4
CS can help create social cohesion through voluntary engagement of citizens, building skills and engaging in problem-solving processes	6.55	2	0.038	ENGOs – Public **Bodies**	**0.0229***	2.43
				ENGOs – Researchers	0.3989	1.11
				Researchers – Public	0.1967	-1.51
CS can help to involve different stakeholders in policy design and management of local ecosystems	15.37	2	0.000	ENGOs – Public	**0.0027***	3.13
				ENGOs – Researchers	0.9311	0.49
				Researchers – Public	**0.0021***	-3.2
Collaboration with volunteers from the general public is usually problematic	10.13	2	0.006	ENGOs – Public	0.0408	-2.21
				ENGOs – Researchers	1	0.09
				Researchers – Public **Bodies**	**0.0066***	2.85

*: Statistically significant difference detected at p ≤ alpha/2, alpha = 0.05 (after Bonferroni adjustment for multiple comparisons).

Table 5. Statistically significant obstacles using the Kruskal-Wallis test, followed by pairwise comparisons using the Dunn-Bonferroni test.

Obstacle	Kruskal-Wallis test			Pairwise comparisons		
	H	df	P-Value	Pairs	P-Value	r
Insufficient legal framework	12.37	2	0.002	ENGOs – Public **Bodies**	0.1703	-1.58
				ENGOs – Researchers	0.3826	1.14
				Researchers – Public **Bodies**	**0.0008***	3.47
Lack of cooperation culture	18.68	2	0.000	ENGOs – Public **Bodies**	0.2361	1.41
				ENGOs – Researchers	0.946	-0.48
				Researchers – Public **Bodies**	0.0255	-2.39

*: Statistically significant difference detected at p ≤ alpha/2, alpha = 0.05 (after Bonferroni adjustment for multiple comparisons)

Lastly, two obstacles were statistically significant amongst the three groups of actors: "Insufficient legal framework" and "Lack of cooperation culture" (Table 5). After the Dunn-Bonferroni post-hoc pairwise comparisons, only the obstacle about the insufficient legal framework revealed a significantly differed pair. This pair was researchers vs public sector employees, with 3.6% of the former and 25.8% of the latter choosing "Insufficient legal framework" as one of the main obstacles to the development of CS in Greece.

Discussion

This study's aim was to understand the perspectives of the three main groups of environmental actors in Greece towards CS. Similar studies about the main initiators of ECS projects (ENGOs, researchers, governmental organisations) are limited.

To our knowledge, no other comparative studies between the main initiating actors of ECS projects (ENGOS, researchers and relevant public bodies) have been conducted in Greece to date. Our initial hypothesis was that the majority of the actors in Greece would not be familiar with the practice. After the completion of the quantitative part of the study, it became evident that the reality in the field was rather different. Therefore, the findings that the three groups of actors have significant differences amongst them (Tables 3, 4 and 5), with researchers being more familiar amongst the three groups, with the most positive group towards CS coming from ENGOs, can be considered as the first of this kind.

Regarding the familiarity with CS, we are not aware of another study that quantitatively depicts the knowledge of the actors concerning the term, the concept or the practice of CS. Nevertheless, at a survey of public familiarity with the CS term and concept, we read "...we found that less than half of respondents were familiar with the term "citizen science," but over 70% were familiar with the concept by another name. (Lewandowski et al. 2017). This is very similar to our questionnaire results where 41.6% knew the term, 65.2% knew the concept and 39.3% have participated in a project with CS characteristics.

We found that, in Greece, the term "Public participation in scientific research" (PPSR) is the most familiar amongst the representatives of the actors and this comes in contradiction with the notion expressed in other studies that PPSR has proven to be difficult to use and that the term "citizen science" is already well-established (Eitzel et al. 2017). Regarding the positive attitude of the actors towards CS, our findings are in agreement with previous studies. For example, Minkman et al. (2017) found that water practitioners in The Netherlands are willing to embrace CS while Riesch and Potter (2014) found that, for scientists participating in Open Air Laboratories (OPAL), CS projects have been a very positive experience.

The term crowdsourcing and crowd science were those for which the actors who took part in the study demonstrated less familiarity (Fig. 1). This is despite the increasing use of participatory research during the past 20 years. Although not synonymous, the terms are part of the gradient in participatory research where science meets society. Both CS and crowdsourcing may facilitate the dialogue between researchers and public and increase the influence of citizens on research agenda formulation. However, there have been increased concerns about crowdsourcing taking over citizen science which may result in displacing other forms of participatory research (Eitzel et al. 2017).

The concerns about data quality collected by citizens are well reported in literature (Burgess et al. 2017) and our study is no exception. Moreover, Riesch and Potter (2014), in exploring the perceptions of scientists about CS, found that the concern of scientists for any disapproval by their colleagues in case they use citizens' data might discourage them from doing so. Nevertheless, the actors in Greece believe, similarly to other studies (Danielsen et al. 2005; Bio Innovation Service 2018), that, with appropriate training, citizens can collect quality environmental data.

Although previous studies suggest that, very often, the main motivation for citizen scientists' involvement is to contribute to science (Raddick et al. 2013; Alender 2016; Land-Zandstra et al. 2016a), according to the opinion of the actors in our study "*citizens do not have enough incentives to volunteer/engage in scientific research*". Either the actors are right that the public in Greece have low incentives for engaging in general or the actors are failing to recognise volunteers' prevalent motivations (Rotman et al. 2012). Previous studies support strongly the opinion of the actors regarding the low levels of volunteering trust and social capital in Greece (Lyberaki and Paraskevopoulos 2002). For example, according to the 2008 European Social Survey, the percentage of Greeks who believe that one needs to be cautious of others and thus not trust them was almost double compared to the European average (Clarke et al. 2015, 11). Many studies have emphasized the crucial importance of trust-based relationships and credibility for a sustainable collaborative environment (Rotman et al. 2012; Stone et al. 2014; Vann-Sander et al. 2016). Such an environment is a must for ECS projects to flourish.

Semi-structured interviews revealed two possible causes regarding the first obstacle i.e. "Lack of cooperation culture". The first is the relationships amongst the three groups of actors (issues of trust, recognition, reward) and the second, a luck of culture of volunteering in Greek society. Those are in agreement with previous studies that argue for the low levels of trust, volunteerism and social capital in Greece (Clarke et al.

2015, 10–11). If we will consider that the fourth and fifth obstacle, "Low levels of trust from citizens to the institutions" (24.7%) and "Lack of incentives on the part of citizens" (23%), respectively, are somehow related with the issue of trust, we understand the multi-faceted influence of this factor.

Finally, our findings regarding the basic reasons of the reduced visibility of CS in Greece are in agreement with previous studies. More specifically, the first reason emerging from the semi-structured interviews conducted with the Greek actors was the under-representation of CS in formal literature. This possibility is well documented in the literature and has mainly two causes. The first one is related to the scientists' concerns about data quality (Burgess et al. 2017) and their perceptions that CS data will not be well received by other scientists (Riesch and Potter 2014). The second one is that some CS projects do not have as their objective peer-reviewed publication, for example, NGO projects that mainly aim to educate or affect policy (Burgess et al. 2017). The other reason for reduced visibility of the term in Greece was the usage of different terms in relevant projects. This finding is also in agreement with other studies reporting on a variety of terms used to describe data arising from citizens (Shirk et al. 2012; Kullenberg and Kasperowski 2016; See et al. 2016; Eitzel et al. 2017). The third obstacle about problematic or no promotion of relevant projects, for example, no website, no relevant articles in the press, is mentioned in a report by Roy et al. (2012), but also by other authors who tried to create indexes of CS projects (Chandler et al. 2017; Pettibone et al. 2017; Pocock et al. 2017; Bio Innovation Service 2018).

Implications for Future CS Attempts and Further Work

A key finding of this study was that a significant percentage of actors in Greece, who are professionally involved in the environmental data collection procedure, are familiar with the term, the concept or the practice of CS. This finding can have important implications for future ECS attempts since it makes clear that familiarity with CS is not the main issue amongst the actors. A practical step following this finding could be the organisation of a congress or a forum about ECS in Greece. Such an event would be important in order to build synergies and trust amongst the actors, that is partly, the number one obstacle to the development of CS in Greece according to the actors.

Since we know which terms are the most familiar within the groups of actors, a possible implication is that the concept of CS can be communicated more effectively in order to be understood by the audience. For example, if we want to communicate the idea to a governmental institution, it is advisable to mention also the terms "community - based environmental monitoring" or "public participation in scientific research" since our chances to convey the concept will significantly increase. The same goes for the ENGOs, mainly for the term "public participation in scientific research".

Our findings showed that all the groups of actors (ENGOs, researchers, public bodies) are positive towards CS, although to varying degrees. This information could be important if we would like to follow the advice of Bonney et al. (2009) "*A successful*

CS project requires a development team comprising multiple disciplines. ... Small groups or organisations that do not have internal access to all disciplines can partner with other organisations or adapt national CS projects for use at local or regional scales.". In Greece, the majority of the organisations are small to medium size, so the idea of partnerships probably is the most viable one. Of course, the issue of trust and the consequent lack of cooperation culture in Greece are the main obstacles to the development of CS in the country. However, a practical result of this study is the specific information arising about each group of actors and which can be used for future efforts. For example, we identified the existence of a legal framework as important factor for the public bodies and compliance to specific data collection protocols important for scientists. Moreover, from the analysis of the Likert scale, we can observe differences amongst the groups of actors in greater detail.

In addition to similarities, the study also highlighted significant differences amongst the group of actors who usually initiate ECS projects. These actors are characterised by different levels of familiarity with CS and relevant terms, they prioritise differently the obstacles and they are more positive or negative towards different aspects of CS. Further studies are needed to understand the motivations of scientists and citizens to engage in collaborative projects. For example, Rotman et al. (2012) found that the motivations of participants shift over time and often the scientists are unaware or mistaken about those. Another study showed that the perceptions about CS between experts and citizens can differ and this can lead to conflicts and distrust (Weng 2015) or that the experts and the citizens have different views of formal and informal environmental sensing data (Jiang et al. 2018). These studies can be supportive especially for building synergies and interdisciplinary ECS working groups. More in-depth research in the direction of assessing the perspectives of the actors towards possible collaborations, needs assessment for building ECS projects, mapping the different organisational skills and aligning them with the needs within the framework of synergies could be of much help for the development of the field. Moreover, research on case studies of ECS projects that are collaborations of ENGOs, governmental organisations and research institutes we believe are of high importance. Lessons learned and best practices could be of much support, especially for similar contexts to Greece where organisations are of small size without specialised know-how. Future qualitative research should be conducted regarding civil servants and especially their point of view for the main obstacle to the development of CS in Greece that was "Lack of cooperative culture". Despite our efforts, their point of view is missing in this study. We believe that is of great importance if we want to understand better the relationships amongst the actors.

The factors that influence the application of CS are diverse and include the specific socio-economic characteristics of each country and geographical regions, history and culture of volunteerism, NGO activity, social capital etc. (Burgess et al. 2017). This study was an exploratory one for Greece and we are aware of at least one in a similar context in Romania (Loos et al. 2015). Despite the fact that the interviews and the questionnaire were carried out in 2018 and significant progress in CS has been made

since then, the results set a baseline for further similar studies in Greece as a means to monitor progress in a fast-expanding field.

The daily use of mobile apps, social media and online platforms has increased familiarity of lay persons with similar tools engaged in CS nowadays (Willis et al. 2017; Zotos and Vogiatzakis 2018). This familiarisation became a necessity during the ongoing COVID-19 pandemic and resulted in a fast-paced mass digital transition. The ability of the actors in Greece and elsewhere to take advantage of this transition, so to create CS online projects, is an important parameter that we have not explored in this study.

As CS advances, new challenges emerge, such as the participants' personal data protection in CS projects (Suman and Pierce 2018). In the European Union, the legal context is quite advanced with General Data Protection Regulation (G.D.P.R) being the main legal text since 2016 (European Parliament and the Council of 27, 2016). However, the level of familiarity and compliance of the actors with G.D.P.R obligations is still variable and should be the focus of future research.

There is a need for more regional studies if we want to better understand the specific challenges to the development of CS - and of citizen engagement in biodiversity and conservation science in general - in modern societies.

Conclusions

Contrary to our initial hypothesis, we demonstrated that the actors in Greece are familiar with and have a positive view of CS to a great extent (majority of respondents in Academia and ENGOs and ca. 50% of public servants). We found significant differences amongst the groups of actors regarding aspects of CS - such as familiarity with it - but also similarities, for example, concerning the main obstacles to the development of CS. We argue for the importance of comparative studies amongst the actors in terms of building knowledge to support synergies and interdisciplinary working groups. The main reasons for the reduced visibility of the term CS in Greece became obvious and are in agreement with previous research. The specific historical and socio-economic context which characterises a country or a geographically-defined area underpins the adoption and implementation of CS. We argue that more studies in different socio-economical contexts and possible comparisons between them, would be of scientific interest and of practical use to formulate public policies. For example, a study from Romania exploring the challenges to initiate a new CS monitoring scheme (Loos et al. 2015) would be of more relevance with the Greek context rather than studies from the US or UK. In addition and given that "ignorance of the existence of the phenomenon" was ranked the second most important obstacle by the actors for the development of CS, there is a need for raising public awareness of CS itself. Towards that direction, a web portal would support further the development of CS in the country by disseminating results beyond the end of each project and create a web presence for projects which currently lack one.

Acknowledgements

We would like to thank the eight interviewees for the willingness and time to participate in this study, namely: Giorgos Theodoridis, Stelios Kazantzis, Christos Arvanitidis, Giorgos Kalliampetsos, Christos Georgiadis, Christina Contaxi, Manolia Vougioukalou and Thomi Vlachogianni. In addition, we are grateful to all those who responded to the questionnaire.

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Appendix I

Questionnaire
Demographics
A1(Q1). What is the type of organisation you represent or work with? (List (radio))
• Environmental NGO
• University / Technological institute
• Research Centre
• Protected area management body
• Decentralised administration / local government
• Ministry
• Natural History Museum
Other
A2(Q2). Name of the organisation you represent or work with (Short free text)
A3(Q3). Working area (List with comment)
• Athens
• Thessaloniki
• Other city (10,000 + residents)
• Town (2,000 up to 10,000 residents)
• Village (up to 2,000 residents)
• I don't answer
A4(Q4). Gender (List (radio))
• Man
• Woman
• I don't answer
A5(Q5). Age (List (radio))
• 18–24
• 25–34
• 35–44
• 45–54
• 55–64
• 65 and above
• I don't answer
A6(Q6). Education level (List (radio))
• I didn't go to school at all
• Secondary education graduation
• Private Institute for Vocational Training
• Public Institute for Vocational Training
• University / Technological institute
• Postgraduate / Doctorate
General questions related to the Citizen Science phenomenon
B1(Q7). As an institution (or as a researcher), have you been involved in an environmental data collection activity? (List (radio))
• Yes

• No
• I don't know / I don't answer
B2(Q8). As an institution (or as a researcher), have you ever involved ordinary citizens as volunteers in environmental actions that you have organised? (List (radio))
• Yes
• No
• I don't know / I don't answer
B3(Q9). Did you know the term 'Citizen Science' before completing the questionnaire? (List (radio))
• Yes
• No
• I don't know / I don't answer
B4(Q10). Do you know any of the following terms? (Multiple choice)
• Public participation in scientific research (PPSR)
• Crowdsourcing
• Volunteered Geographic Information (VGI)
• Crowd science
• Community-based environmental monitoring
• None of the above
B5(Q11). As an institution (or as a researcher), have you been involved in a scientific programme for collecting environmental data with Citizen Science features i.e. involving ordinary citizens?
(List (radio))
• Yes
• No
• I don't know / I don't answer
Attitudes, Perceptions, Obstacles
C1(Q12). How much do you agree with the following statements? - A lot, Significantly, a little, not at all, I don't know / I don't answer - (By the term Citizen Science, we mean scientific activities in which ordinary citizens participate voluntarily in the collection of data and/or in the analysis and/or dissemination of a scientific work) (Array)
• Citizen Science can support the collection of environmental data on a large geographic scale
• Data gathered by citizens is not sufficiently reliable to use for public policy
• Citizen Science can help environmental awareness of ordinary citizens
• The quality of environmental data collected by non-professionals (ordinary citizens) is inadequate for scientific research
• Citizen Science can contribute to the collection of environmental data in cases of limited resources (Time, Money)
• Increasing the phenomenon of citizen science may pose a threat to some jobs of professional scientists
• Citizen Science can support government agencies in collecting environmental data as a cost-effective alternative

• Citizen Science can help democratise science through the involvement of citizens in scientific processes
• The collection of environmental data with low-cost devices, such as smartphone sensors, is unacceptable in the context of scientific research
• Citizen Science can help create social cohesion through voluntary engagement of citizens, building skills and engaging in problem-solving processes
• Citizens do not have enough incentives to volunteer in scientific research
• Citizens cannot follow the protocols required by the collection of environmental data in the context of scientific work
• Citizen Science can help to involve different stakeholders in policy design and management of local ecosystems
• Citizen Science can help to create creative activity for people outside the labour market, for example, retirees
• With appropriate training, ordinary citizens can collect environmental data of satisfactory quality
• Citizen Science can support local communities to protect the environment
• Collaboration with volunteers from the general public is usually problematic
• The resources required (time, money) for a citizens' science programme are excessive in relation to the results it generates

C2(Q13). What do you think are the main obstacles to the development of the Citizen Science phenomenon in Greece? Please select no more than 3 replies (Multiple choice)
• Insufficient legal framework
• Ignorance of the existence of the phenomenon
• Lack of cooperation culture
• Disapproving types of behaviour and attitudes by members/employees, for example, negative attitude from the management
• Lack of incentives on the part of citizens
• Lack of know-how (technical issues, volunteer management …)
• Lack of resources (time, money)
• Low levels of trust from citizens to the institutions
• Lack of incentives on the part of the institutions (distrust of the results of such a programme, for example, data quality)
• Internal issues of organisational nature (e.g. rigidity, bureaucracy)
• Typical requirements for compliance to specific data collection protocols
• Possible conflicts of interest, for example, employees who are employed in data collection to treat it as a threat
• I do not know / I do not answer
• Other

C3(Q14). Do you think that a Citizen Science programme would offer something positive to your organisation's activities or to the research you are conducting? (List with comment)
• Yes
• No

• I don't know / I don't answer
Question for interview
D1(Q15). In the case of a telephone interview for the purposes of this diploma thesis (duration of 30' up to 60' minutes) (List with comment)
• I would probably be positive
• Maybe
• In no case
D2. Contact info, email (Short free text)

Appendix 2

Table A1. List of Interviewees.

Interviewee number	Role	Date
Interviewee 1	Employee at the Environmental Organisation for Wildlife and Nature CALLISTO	26 June 2018
Interviewee 2	Member of environmental NGO "Ecological Collaboration"	28 June 2018
Interviewee 3	Programme/Policy Officer at The Mediterranean Information Office for Environment, Culture & Sustainable Development (MIO-ECSDE)	17 June2018
Interviewee 4	Associate researcher Institute of Environmental Physics and Sustainable Development, National Observatory of Athens, Greece	27 June 2018
Interviewee 5	Senior Researcher at Institute of Marine Biology, Biotechnology and Aquaculture (IMBBC), Hellenic Centre for Marine Research (HCMR)	27 June 2018
Interviewee 6	Researcher at Museum of Zoology of the National and Kapodistrian University of Athens	28 June 2018
Interviewee 7	Employee at the environmental NGO Hellenic Ornithological Society	6 July 2018
Interviewee 8	Director of environmental NGO MEDITERRANEAN SOS Network	5 July 2018